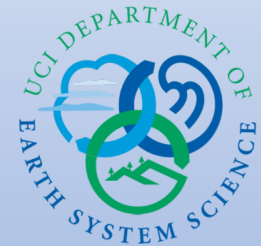


# *Using Aura MLS observations to model budget terms, strat- trop fluxes, and surface variability of $N_2O$*



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AGU PUBLICATIONS

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RESEARCH ARTICLE

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Key Points

- Satellite-based estimates of atmospheric methane are used to constrain the methane budget of the troposphere and stratosphere by combining retrieved methane with atmospheric methane concentration
- Results improve estimates for present anthropogenic methane emissions

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## Measuring and modeling the lifetime of nitrous oxide including its variability

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**Abstract** The lifetime of nitrous oxide, the third-most important greenhouse-emitting greenhouse gas, is based

# This work began with assessing the lifetime of N<sub>2</sub>O. 2005-2010

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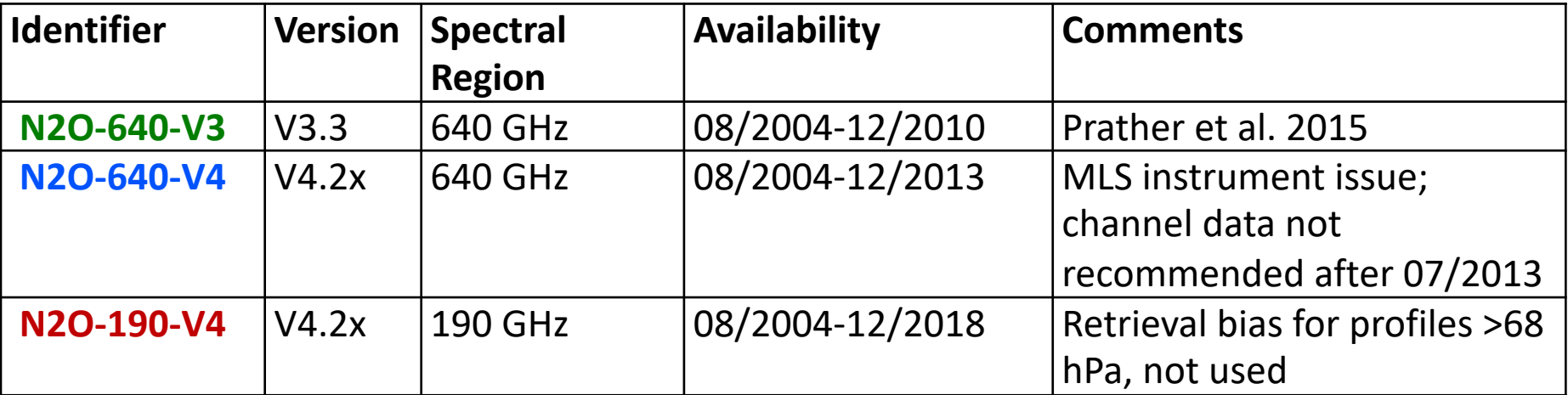
on the atmospheric lifetime of nitrous oxide (N<sub>2</sub>O). This is the uncertainty in the current budget and 21st century projections of N<sub>2</sub>O are its lifetime and the feedback that an N<sub>2</sub>O perturbation has on its lifetime (Prather, 1996). Assessment of the lifetime and feedback is not presently absent from climate and ozone assessments. Atmospheric forcing on climate change (IPCC, 2007; RASO, 2011; IPCC, 2013a) has received more attention in the past couple years (Stratospheric Perturbations and their Role in Climate (SPARC), 2013; Chiperafeld et al., 2014; RASO, 2014).

In this paper we combine satellite measurements of N<sub>2</sub>O, O<sub>3</sub>, and temperature (7 from the Aura Microwave Limb Sounder (MLS) instrument (Lambert et al., 2007; Frohman et al., 2008; Schwartz et al., 2008) with global

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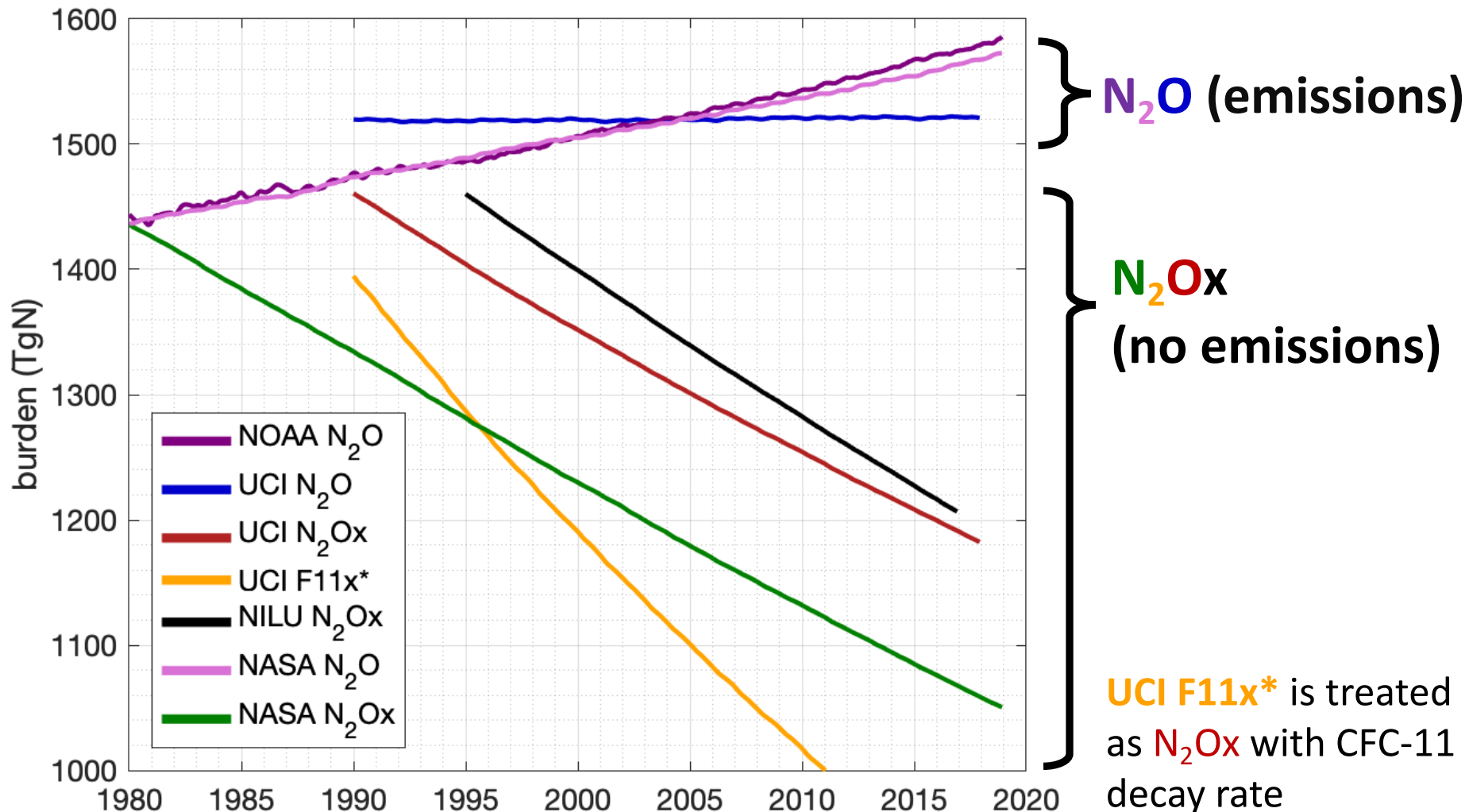
NITROUS OXIDE AND ITS CHANGING LIFETIME

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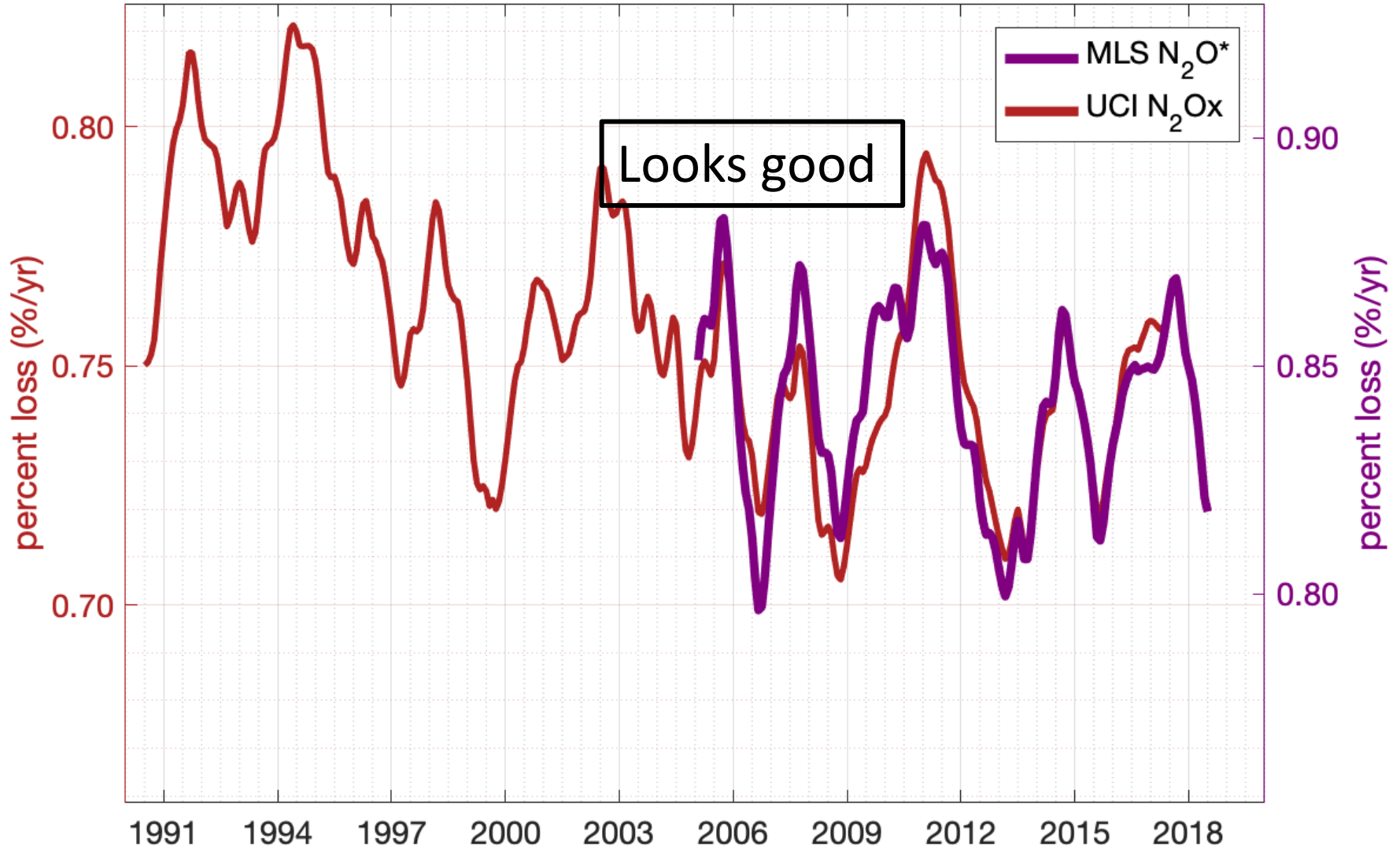


# **N<sub>2</sub>O – MIP** (UCI CTM, NASA GMI, NILU LMDZ5)

**Decay** per N-tracers are simulated in the absence of surface emissions to preserve the stratospheric signal



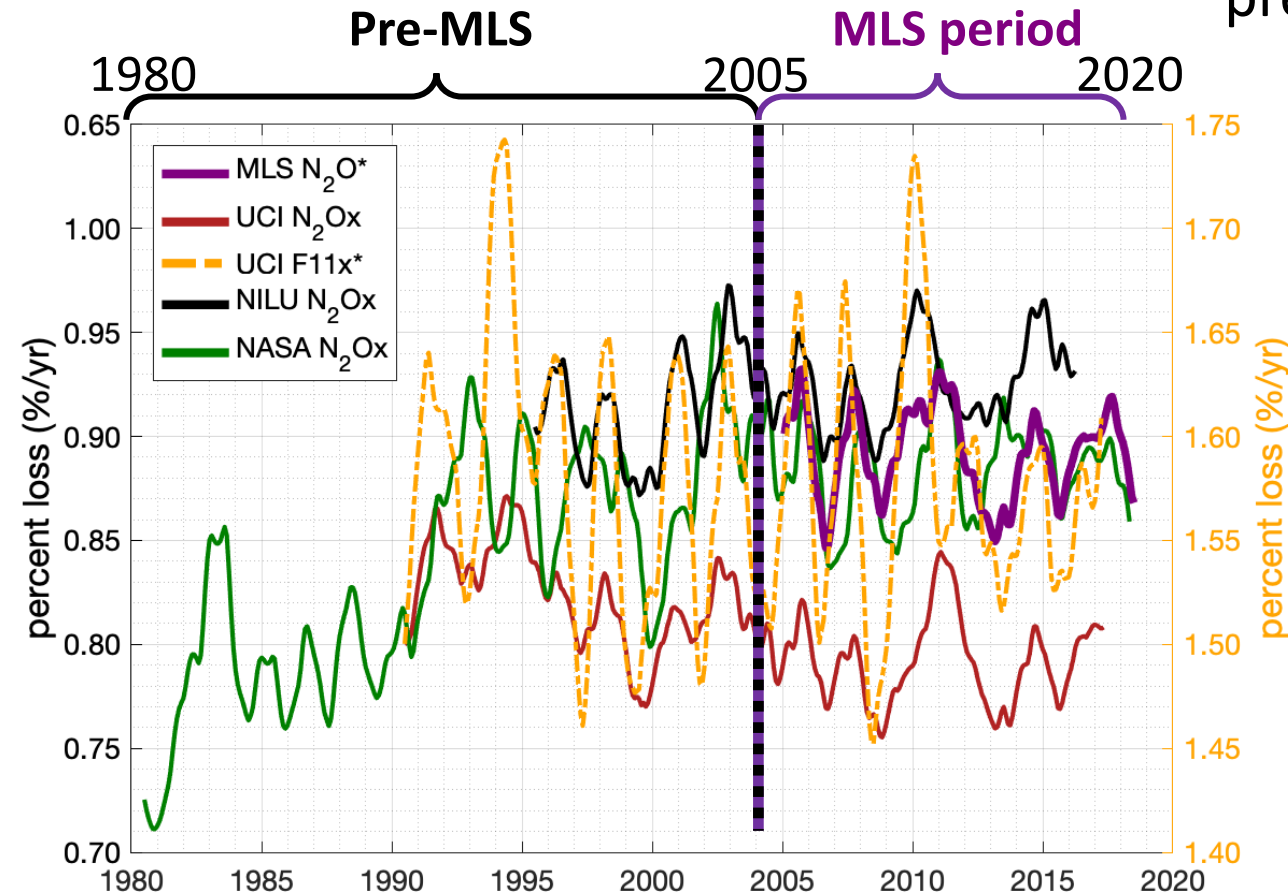
# Measurements vs Models



MLS  $N_2O^*$  uses NOAA HATS  $N_2O$  burden for 2005-2018 (ppb)

# Measurements vs Models

Was N<sub>2</sub>O loss different pre-MLS?  
**Yes**



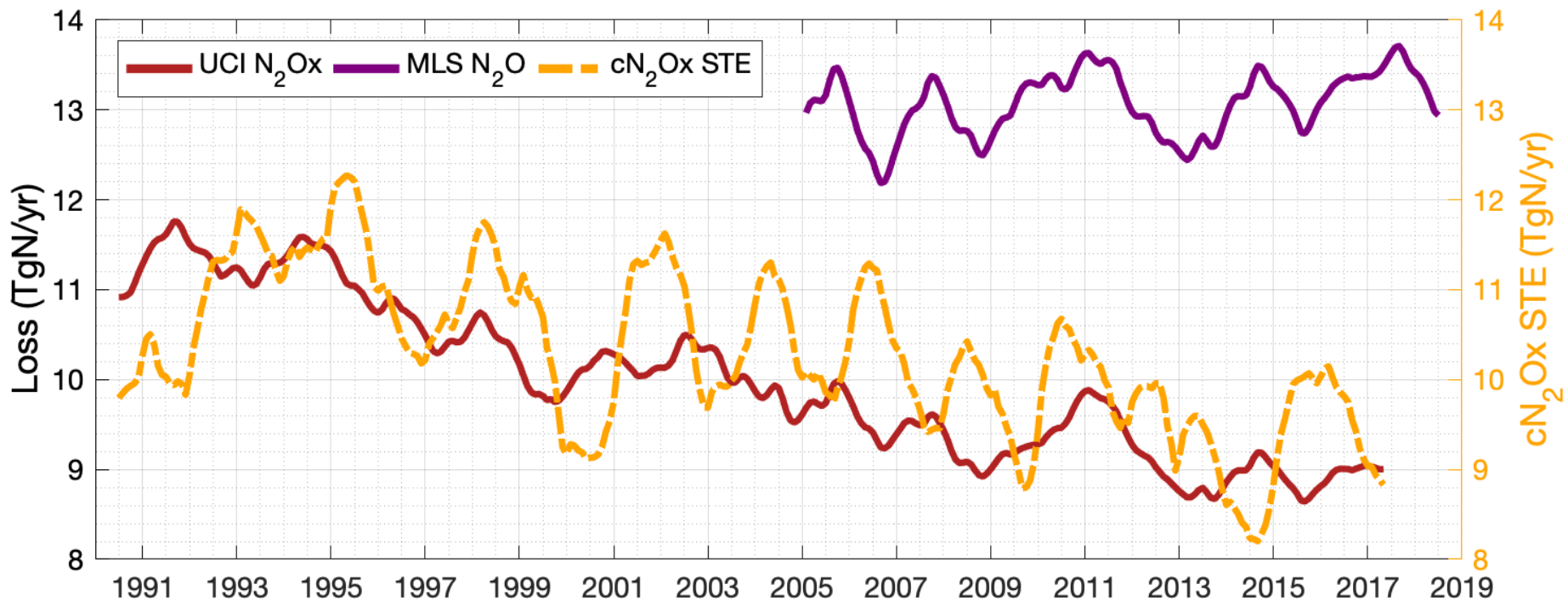
MLS overlap period	Mean Loss	Mean LT
UCI N <sub>2</sub> Ox	0.74%/yr	135 yrs
UCI F11x	1.58%/yr	63 yrs
MLS N <sub>2</sub> O	0.84%/yr	119 yrs
NILU N <sub>2</sub> Ox	0.88%/yr	114 yrs
NASA N <sub>2</sub> Ox	0.80%/yr	125 yrs
Entire period	Mean Loss	Mean LT
UCI N <sub>2</sub> Ox	0.76%/yr	132 yrs
UCI F11x	1.58%/yr	63 yrs
NILU N <sub>2</sub> Ox	0.87%/yr	115 yrs
NASA N <sub>2</sub> Ox	0.83%/yr	120 yrs

MLS N<sub>2</sub>O\* uses NOAA HATS N<sub>2</sub>O burden for 2005-2018 (ppb)

UCI F11x\* decay corresponds to the right axis. All others correspond to the left.

# Complementary N<sub>2</sub>O (Neg-N<sub>2</sub>O) flux vs N<sub>2</sub>O(x) loss

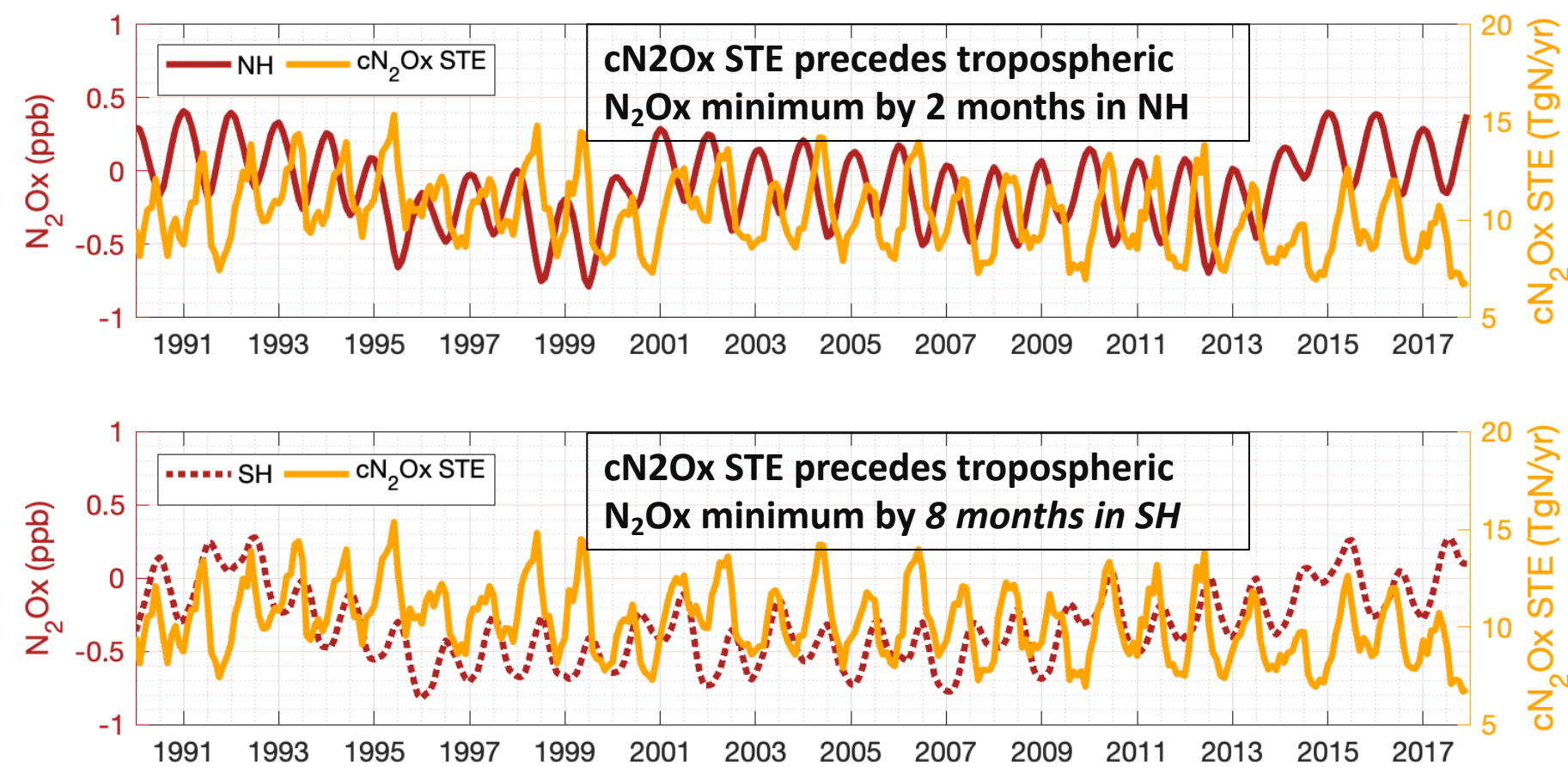
Stratospheric N<sub>2</sub>O loss leads to peak neg-N<sub>2</sub>O flux ~1 year later



X-correlation w/ cN <sub>2</sub> Ox STE	Offset
MLS N <sub>2</sub> O loss	-1.0 yrs
UCI N <sub>2</sub> Ox loss (MLS overlap period)	-0.9 yrs
UCI N <sub>2</sub> Ox loss (entire period)	-1.0 yrs

cN<sub>2</sub>Ox: every N<sub>2</sub>Ox molecule lost produces one cN<sub>2</sub>Ox molecule

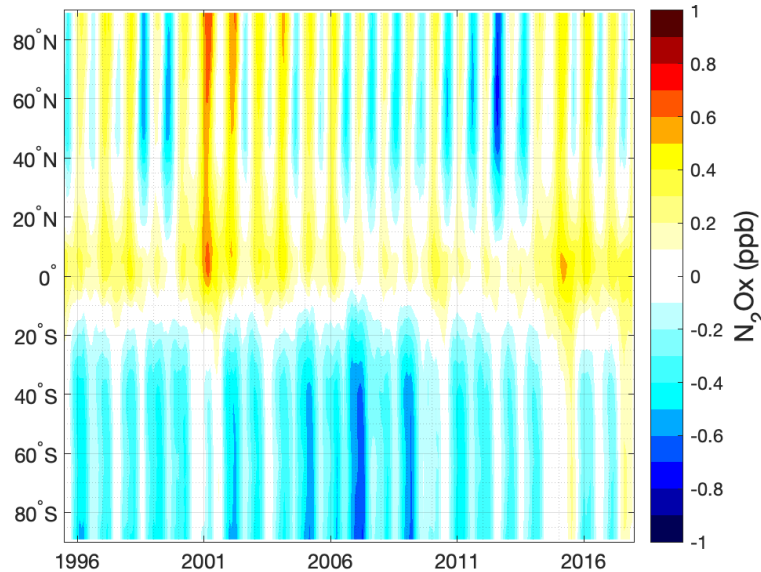
# Monthly Tropospheric **N<sub>2</sub>O<sub>x</sub>** vs total **cN<sub>2</sub>O<sub>x</sub> STE flux**



X-correlation w/ <b>cN<sub>2</sub>O<sub>x</sub> STE</b>	Offset
<u><b>UCI N<sub>2</sub>O<sub>x</sub> Northern Hemisphere</b></u>	+0.2 yrs
<u><b>UCI N<sub>2</sub>O<sub>x</sub> Southern Hemisphere</b></u>	+0.7 yrs

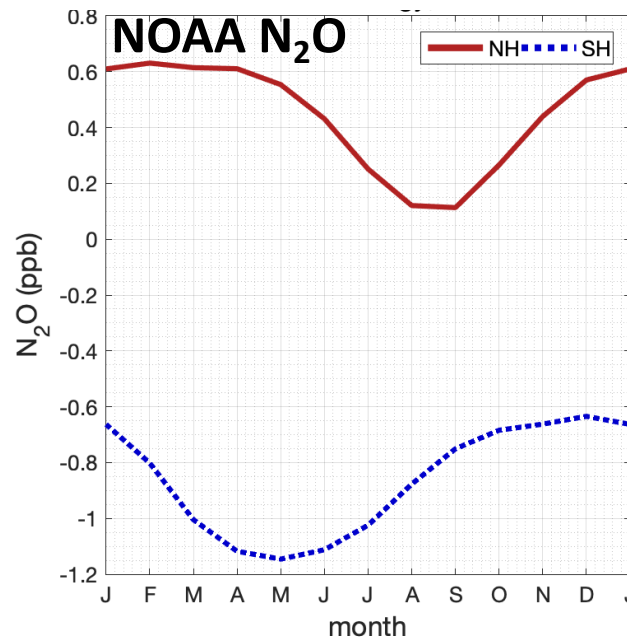
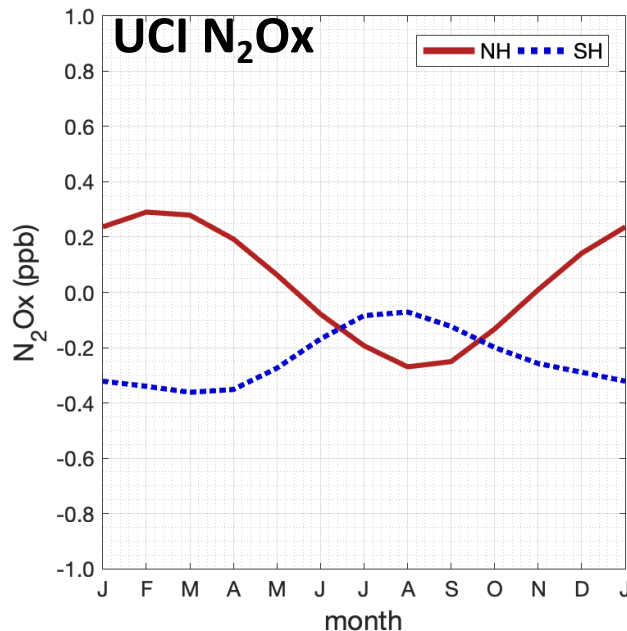


# Surface N<sub>2</sub>Ox: Seasonal cycle of stratospheric loss



- **North** Larger seasonal amplitude
- **South** < **North**

## Monthly surface climatologies

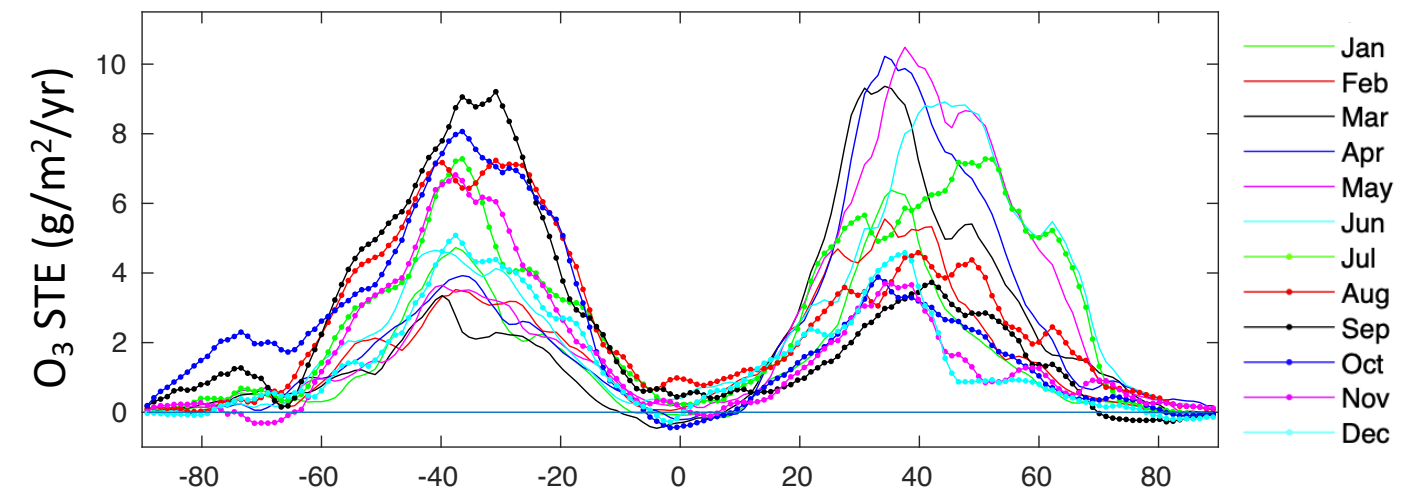


UCI N<sub>2</sub>Ox (no emissions) agrees with NOAA NH seasonal cycle

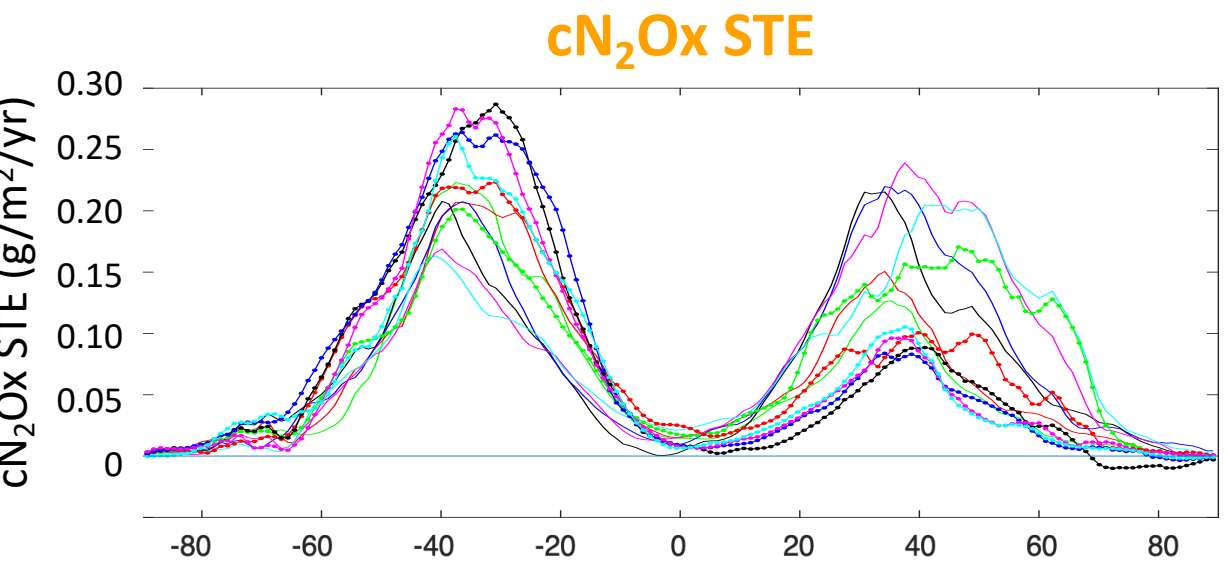


# UCI CTM STE: How do the STE fluxes compare in each hemisphere?

**O<sub>3</sub> STE**



Annual **O<sub>3</sub> STE** is symmetrical

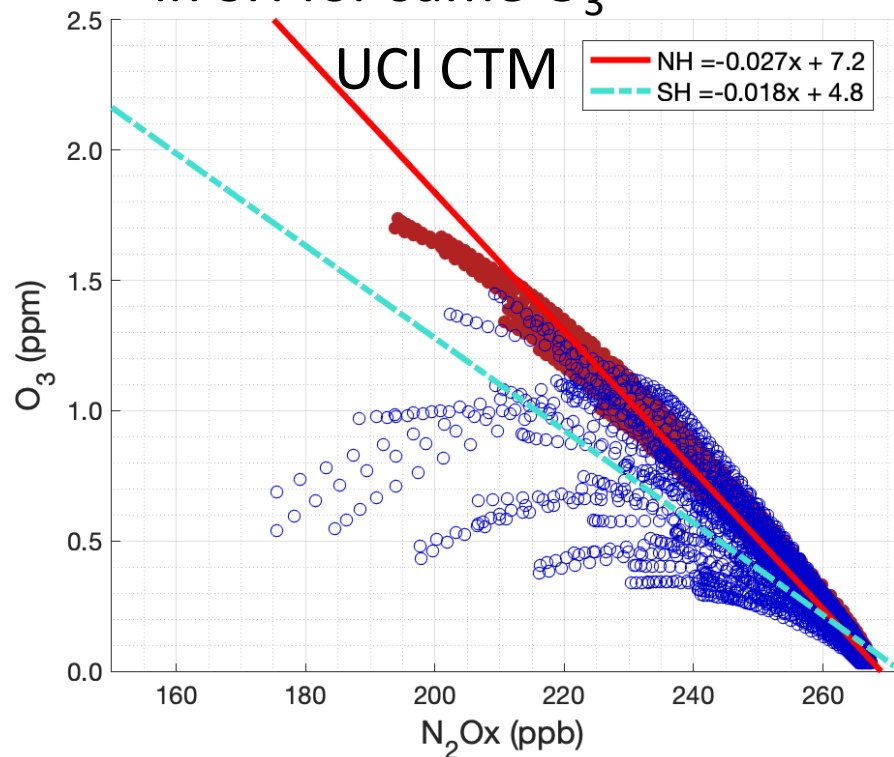


STE Flux	O3 (Tg/yr)	cN2Ox (Tg/yr)
Total	349	11.2
NH	185	4.6
SH	164	6.6
S:N Ratio	0.9	1.4

**negative-N<sub>2</sub>O STE** SH > NH (mechanism not understood)

# N<sub>2</sub>O vs O<sub>3</sub> Tracer Correlations:

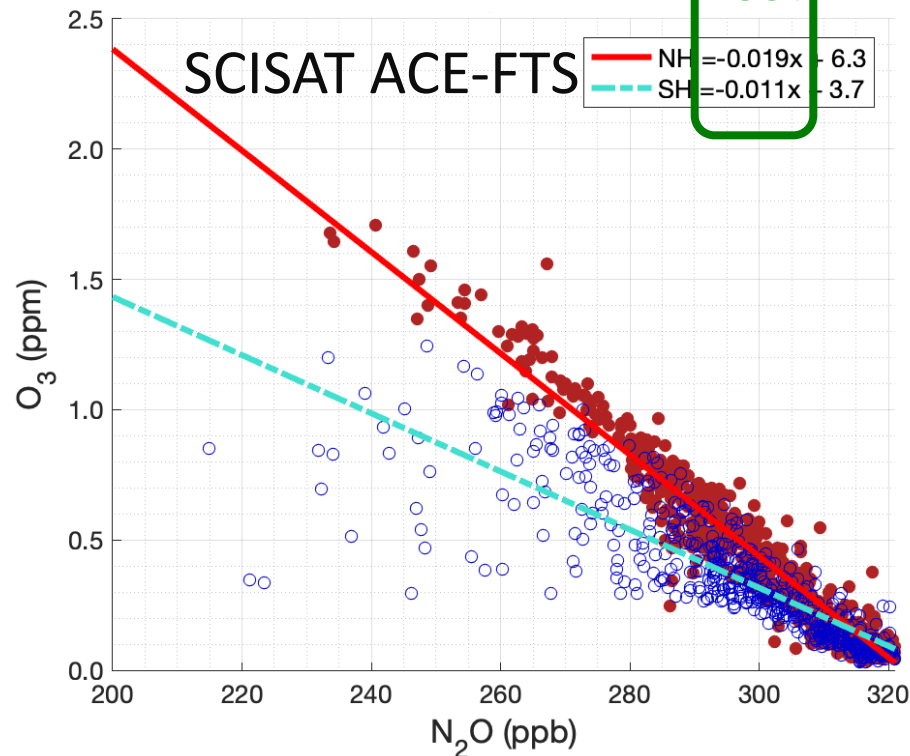
Lower N<sub>2</sub>O<sub>x</sub> (no emissions)  
in SH for same O<sub>3</sub>



- Hemispheric difference due to increased transport of depleted-N<sub>2</sub>O air into SH?

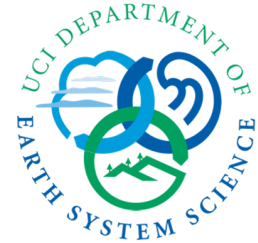
Do we see hemispheric  
asymmetry in  
observations?

Yes!



\*Data > 70° were not used due to retrieval limitations of ACE orbit

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- Jet Propulsion Laboratory – Lucien Froidevaux
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- NOAA – James Elkins, Geoff Dutton
- NASA – Ken Jucks